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PROGRESS AND PLANS OF A REMOTE SENSING PROGRAM FOR THE INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES (IFYGL)

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ABSTRACT

ERTS-1 coverage of the 32,000 square mile Lake Ontario Basin is being used to study short term and seasonal changes which affect many aspects of water problems in the Great Lakes. As part of the International Field Year for the Great Lakes (IFYGL) -- a coordinated, synoptic study of the Lake Ontario Basin--processed ERTS-1 imagery will contribute to the data base of synchronized observations being made by investigators from many U.S. and Canadian government agencies and universities. The first set of ERTS data has been received and will be processed shortly for parameters of hydrological and limnological significance--such things as land use, terrain features, and water quality. When complete, nine ERTS-1 frames recorded during a substantially clear period, August 19, 20, and 21, will provide coverage of the entire Basin.

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Seven frames show all but a small portion of the southern and eastern-end of the Basin (Figures 1 and 2). Many drainage basin characteristics are clearly identifiable on the imagery.

BACKGROUND

ERTS-1 is contributing significant data to the International Field Year for the Great Lakes (IFYGL). The IFYGL is a synoptic study of a major lake system--the Lake Ontario Basin. It is a coordinated plan for synchronized observations by investigators from numerous agencies and universities in the U. S. and Canada and is an official task of the International Hydrological Decade--1965 through 1974. Data collection for the Field Year will occur from April 1972 to April 1973.

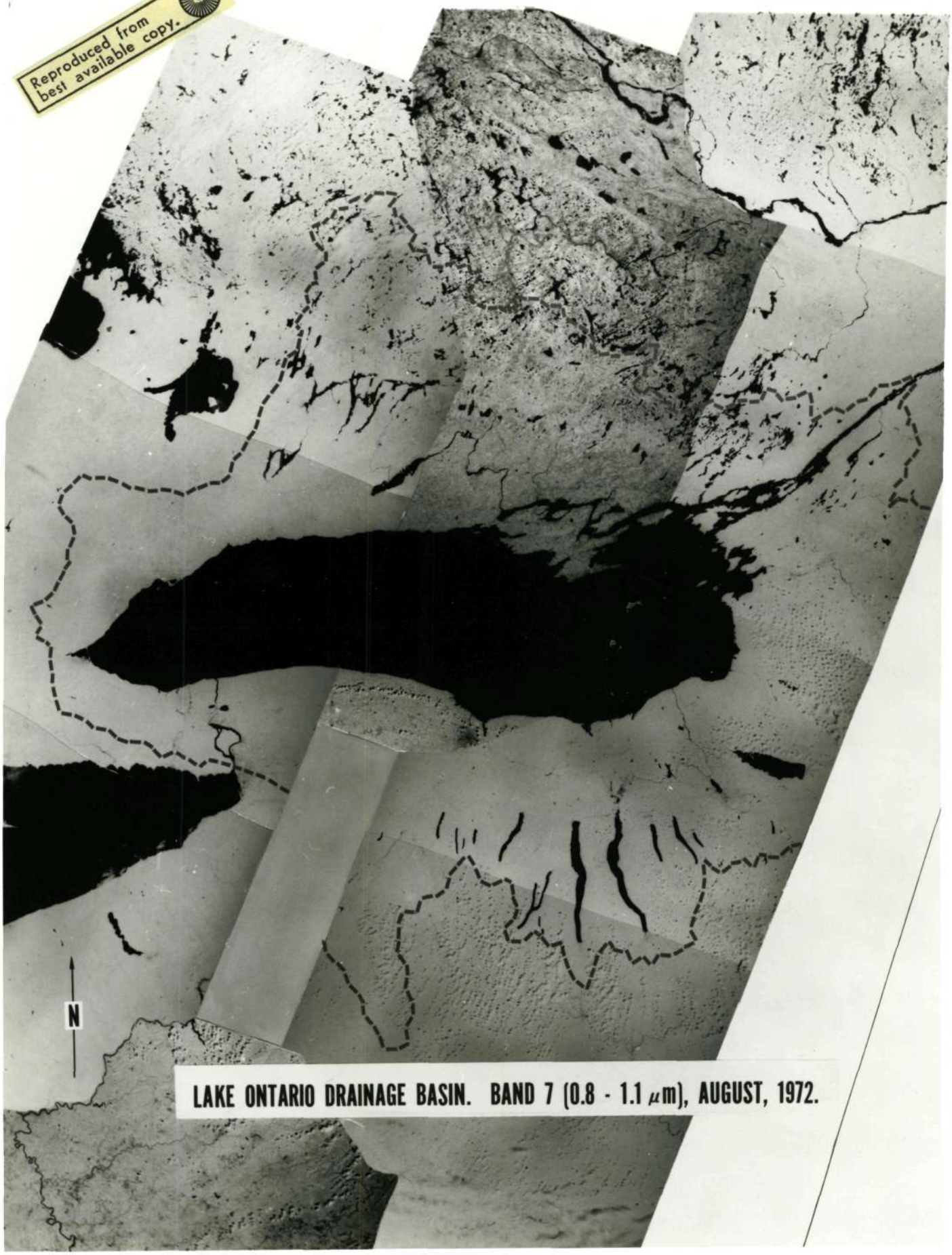
As part of the IFYGL, the Environmental Research Institute of Michigan, formerly Willow Run Laboratories is processing and analyzing available ERTS-1 data of the Lake Ontario Basin. Subsequently, it is expected that all IFYGL investigators will have access to the data and results through the IFYGL data banks and NOAA, the U. S. lead agency.

CURRENT REMOTE SENSOR DATA

Since 1970 we have been preparing for analysis of remote sensor data from the Field Year. Under sponsorship of the U. S. Corps of Engineers two aircraft flights were made over selected portions of the Basin in the spring of 1971.

LAKE ONTARIO DRAINAGE BASIN. BAND 5 (0.6 - 0.7 μm), AUGUST, 1972.

FIGURE 1



LAKE ONTARIO DRAINAGE BASIN. BAND 7 (0.8 - 1.1 μm), AUGUST, 1972.

FIGURE 2

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These flights were used to obtain photographic, multispectral scanner, and radar data for the development and evaluation of remote sensing concepts and techniques to be used during the Field Year. Computer-implemented enhancement and classification of terrain and water features were demonstrated and in several cases, coupled with predictive thermal and water quality models.

Under NASA and EPA sponsorship three successful aircraft data-collection missions over the Basin have been conducted since the official start of the Field Year. Two additional missions are projected before the end of April 1973. NASA is also providing invaluable high-altitude photographic data of the western portion of the Basin during the Field Year through periodic flights of its RB-57 research aircraft. A number of other remote sensing aircraft from both the U. S. and Canada are contributing to collection of synoptic data during the Field Year. The aircraft data will have an important role in relating ground observations and field measurements to satellite collected data.

To date the period August 19-21 has been the only period since the launch of ERTS-1 in which the Basin was substantially free of clouds and haze at the time of ERTS overpasses. Seven frames of data comprising all but a southern and eastern portion of the Lake Ontario Basin were used to construct mosaics of the Basin in spectral Band 5 and Band 7.

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INTERPRETATION OF ERTS MOSAICS

The Lake Ontario Drainage Basin extends from 41° 50' N to 45° 23' N latitude and 74° 0' W to 80° 13' W longitude. The land area is almost equally divided between the U. S. and Canada--the Canadian portion being entirely within the Province of Ontario and the U. S. portion, in western and upper New York State, with a narrow projection extending into Pennsylvania.

The ERTS-1 mosaic of the Basin in Band 5 (0.6-0.7 μm) clearly shows cultural features. Patterns of transportation, land use, and development are seen to be associated with the proximity of the Lake--with the heavily urbanized areas adjacent to the lake shore. The mosaic shows the decreasing intensity of land utilization as distance from the lake increases--a characteristic particularly marked in the Canadian portion of the Basin. Adjacent to the Canadian lake shore are the major urban areas of Hamilton, Oakville, Toronto, Oshawa, Belleville, and Kingston. North of these cities a band of agricultural land 15 to 30 miles wide extends through the Basin parallel to the northern lake shore. Above this band of agriculture are the numerous lakes and forests of the Canadian shield. The urban areas are identifiable by their light tones on the imagery while the agricultural areas show the regular grid network of main and secondary feeder roads and salt-and-pepper contrasts of cultivated fields. The northern shield area, with its sparse roads, appears in even dark grey tones, representing the boreal forest. To a lesser extent, this pattern of decreasing intensity of land utilization from the lake shore is also true

for the U. S. portion of the Basin--Rochester, Oswego, and Watertown being the major identifiable urban areas adjacent to the Lake.

At 43° N latitude (approximately the southern shore of Lake Ontario) there is a 37% overlap of ERTS coverage obtained on successive days. Thus, with good fortune, certain short-term events may be recorded twice within 24 hours. Such dynamic features as effluent plumes of rivers and industrial outfalls can be observed. Comparison of the Niagara Plume, recorded on ERTS imagery obtained on August 20 and 21, shows an easterly trend to the Plume on both days. The Plume is indicated by the contact of a dark area (the Plume) at the mouth of the Niagara River and the somewhat more turbid appearing waters emanating from the western end of the Lake--particularly the outfall of Welland Canal at Port Weller. The western end of the Lake, with high concentrations of urban and industrial areas along its shore, has a considerably more turbid appearance than the waters of the eastern end of the Lake. ERTS-1 imagery is likely to provide information on large-scale mixing patterns not obtained by other means.

The ERTS-1 mosaic of the Basin in Band 7 (0.8-1.1 μm) provides excellent contrast between land and water areas. Indeed several of the major geological features which affect surface hydrology are discerned by the patterns of lakes and land. Relatively large lakes occur in areas of somewhat impervious shale bedrock--examples; the Finger Lakes country of the southern portion of the Basin, and Oneida Lake, near Syracuse. Soluble bedrock areas such as limestone and dolomite are identifiable by the general lack of lakes or surface streams. Such areas include the western end of the Basin, the Niagara Peninsula, and a

band along the southern shore of the lake.

Most impressive in the Band 7 mosaic is the complexity and fine detail shown in areas of crystalline rocks in the northern and eastern portion of the Basin. Fault and fracture zones in this region are commonly indicated by narrow linear lakes and strings of small lakes and ponds. The high contrast between land areas and surface water make this band most useful for recording these hydrological features. The Band 7 mosaic provides perhaps the most detailed surface water map ever constructed of the Lake Ontario Basin.

The availability of extensive data collected from aircraft allows the temporal and spatial extension of the results of local IFYGL studies to the remainder of the Basin through the use of ERTS-1 imagery. For example, the physical "representativeness" of selected and closely-studied Representative Basins can be assessed by their comparison with other portions of the Lake Ontario Basin on ERTS imagery.

DATA PROCESSING

Three types of processing techniques are expected to aid in extraction of useful information from ERTS-1 data--level slicing, channel ratioing and multispectral "signature" recognition. The level slicing and the channel ratioing are essentially scene enhancement techniques; multispectral recognition is used for discrete classification of scene elements.

Level slicing (or "thresholding") is accomplished in such a way that all recorded MSS signals above or below a certain value in a single band are

automatically recorded separately from the signals for the remainder of the scene. In this way certain terrain features, which are identifiable by their discrete signal level in that band, can be singled out and mapped as a separate image.

In the channel ratioing technique two channels of ERTS-MSS data will be used. The signals in one channel will be divided by the signals of the other channel to produce a new image. The new ratioed image essentially eliminates similarities which occur between the two channels and emphasizes slight spectral differences in the two channels. Thus marked contrast enhancement occurs between objects that appear spectrally different in the two channels. Also the ratioing technique has the effect of reducing distortions of the scene due to illumination variations (cloud shadows) and radiance variations due to terrain slope and aspect. The results of ratioed ERTS-MSS data will be useful for enhancing the interpretability of the images and may also be further processed using level slicing or signature recognition techniques.

Recognition processing makes use of all four ERTS-MSS channels at once. Discrete spectral "signatures" are obtained from known terrain or water areas. A "signature" is the reflectance characteristics of an object of interest in all four bands. Once programmed into the computer, all scene elements having similar spectral characteristics to the known signature are automatically identified and printed out by the computer. If spectral signatures are available for significant scene elements, a scene image with the locations and areal extent of these features is produced. Also area statistics can be obtained from

such computer classified data.

EXAMPLES OF DATA PROCESSING TECHNIQUES

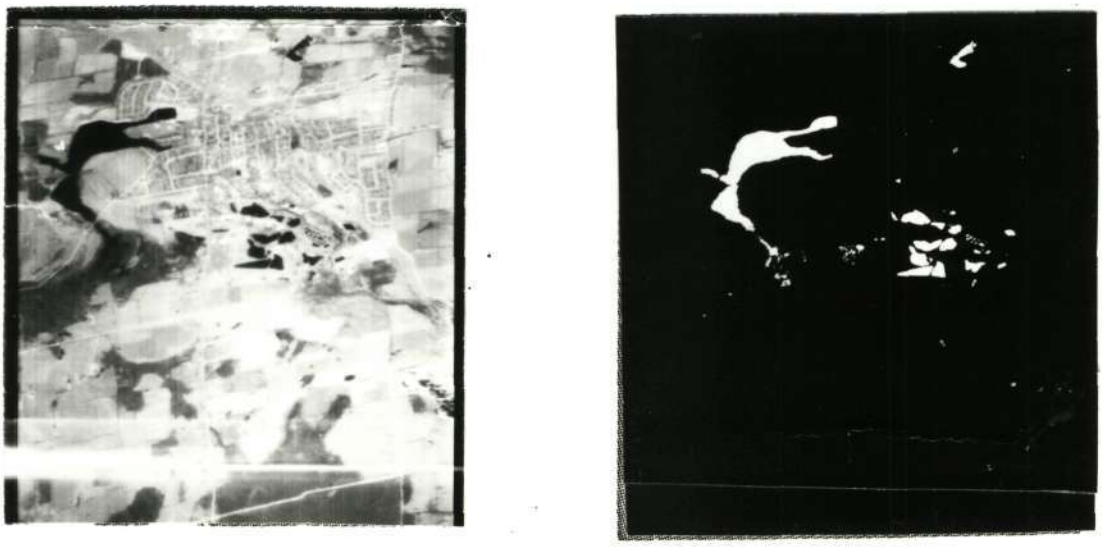
Figure 3 and 4 illustrate the processing results of the three techniques described above. These MSS data were collected from aircraft as part of the IFYGL effort of the Willow Run Laboratories. Processed ERTS data will be similar in nature but not in detail. Shown with the processed aircraft data are details as small as 10 ft on a side; ERTS has a minimum resolution of about 300 ft.

ANTICIPATED RESULTS

ERTS data is expected to contribute primarily to the following two broad areas of IFYGL efforts:

Terrestrial Water Balance: The storage, runoff, and evaporation of water from the terrestrial portion of the Basin is governed by a number of factors--several of which are subject to satellite observation. Water stored in ponds, lakes, and reservoirs and in the form of snow and ice can be monitored on ERTS imagery. Also the reflectance of the soil surface may be an indicator of the water stored in the Basin as soil moisture. Runoff of precipitation is determined, in part, by the nature of the terrain surface. Where differences in land use exist, differences in amounts and rates of runoff can be expected.

ORIGINAL DATA PROCESSED IMAGE



a) Video and a level slice of a near infrared channel for discrimination of areas of surface water (white). Acton, Ontario, 5-11-71.

b) Video image containing cloud shadows and an enhanced image. Light areas of the enhanced image are natural and crop vegetation; dark areas are bare soil. Elora, Ontario, 6-17-72.

FIGURE 3. EXAMPLES OF LEVEL SLICED AND ENHANCED (RATIO) IMAGES.

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VIDEO IMAGE (0.62-0.68 μm)

RECOGNITION IMAGE

Color Code

Ponds	- Blue
Woodlots	- Dark Green
Herbaceous Vegetation	- Olive Green
Bare Soil	- Brown
Gravel	- Orange

FIGURE 4. EXAMPLE OF MULTICHANNEL RECOGNITION PROCESSING USING SIX SPECTRAL BANDS. MILTON, ONTARIO. 5-11-71, ALTITUDE: 8000 FT.

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Also rates of evaporation are affected by land use. A generalized land-use map of the Lake Ontario Basin with complementary statics of the areal extent of each use will be one output of the processing of ERTS-1 data. The mid-August 1972 data will probably be used for this purpose.

Water Quality and Currents: As part of this project, recent success in mapping and characterizing differences in water quality related to suspended sediments, effluent discharges, and biological organisms from aircraft data will be extended to ERTS-MSS data. The extent, nature, and seasonal variation of the Niagara Plume, as well as the Toronto Harbor are areas which will be studied in some detail by IFYGL investigators.